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STATE OF WASHINGTON
ENVIRONMENTAL HEARINGS OFFICE
4224 - 6th Avenue SE, Bldg. 2, Rowe Six
P.O. Box 40903, Lacey, WA 98504-0903

February 17, 2000

Daniel D. Zender
and Robert A. Carmichael
VISSER ZENDER & THURSTON
PO Box 5226
Bellingham WA 98227

Cheryl A. Nielson
Assistant Attorney General
Department of Natural Resource
PO Box 40100
Olympia WA 98504-0100

RE: FPAB NO. 00-001
CROWN PACIFIC LIMITED PARTNERSHIP v. DNR

Dear Parties:

Enclosed is a Motion, Stipulation and Order Approving Settlement Agreement and Final Prescriptions for the Acme Watershed Analysis.

Very truly yours,

William A. Harrison

Hon. William A. Harrison
Administrative Appeals Judge

WAH/jg/F 00-001
enc.

CERTIFICATION

On this day, I forwarded a true and accurate copy of the documents to which this certificate is affixed via United States Postal Service postage prepaid to the attorneys of record herein.

I certify under penalty of perjury under the laws of the State of Washington that the foregoing is true and correct.

DATED 2-17-00, at Lacey, WA.

Tracey L Johnson

BEFORE THE
FOREST PRACTICES APPEALS BOARD
STATE OF WASHINGTON

CROWN PACIFIC LIMITED PARTNERSHIP, a Delaware limited partnership, Appellant, v. STATE OF WASHINGTON DEPARTMENT OF NATURAL RESOURCES, Respondent.	No. 00-1 MOTION, STIPULATION, AND ORDER APPROVING SETTLEMENT AGREEMENT AND FINAL PRESCRIPTIONS FOR THE ACME WATERSHED ANALYSIS

MOTION

Appellant Crown Pacific Limited Partnership (Crown) through its attorneys Daniel D. Zender and Robert A. Carmichael, and the Department of Natural Resources (Department) through its attorneys Christine O. Gregoire, Attorney General, and Cheryl A. Nielson, Assistant Attorney General, move the Board for an order approving the Settlement Agreement attached as Exhibit A and dismissing this appeal.

STIPULATION

The basis for this motion is resolution between the parties of the issues giving rise to this appeal. The Parties agree to the terms and provisions of the Settlement Agreement attached as Exhibit A and incorporated herein (Settlement Agreement).

VISSER, ZENDER & THURSTON
Attorneys for Appellants

By: Robt A. Carmichael
for Daniel D. Zender, WSBA #7211 — February 8, 2000

By: Robt A. Carmichael
Robert A. Carmichael, WSBA # 14008 — February 8, 2000

CHRISTINE O. GREGOIRE
Attorney General

Cheryl A. Nielson
Cheryl A. Nielson, WSBA #20163 — February 8, 2000
Assistant Attorney General, for Respondent

ORIGINAL

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Bellingham, WA 98227
(360) 647-1500 Fax (360) 647-1501

ORDER

Based upon the stipulation of the parties, the terms and provisions of the attached Settlement Agreement including the Exhibits thereto, and the justifications therein contained for the revised prescriptions, now therefore:

IT IS HEREBY ORDERED that the Settlement Agreement is approved and the prescriptions set forth therein as Exhibit G shall be the final prescriptions for the Acme Watershed Analysis.

Presented By:

VISSER, ZENDER & THURSTON
Attorneys for Appellants

By: Robt A. Carl
for Daniel D. Zender, WSBA #7211

By: Robt A. Carl
Robert A. Carmichael, WSBA # 14008

CHRISTINE O. GREGOIRE
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Assistant Attorney General, for Respondent

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Bellingham, WA 98227
(360) 647-1500 Fax (360) 647-1501

DONE this 17th day of February, 2000.

William A. Harrison

HONORABLE WILLIAM A. HARRISON
Administrative Appeals Judge

FOREST PRACTICES APPEALS BOARD

Martin R. Kaatz

DR. MARTIN R. KAATZ, Chair

Robert E. Quoidbach

ROBERT E. QUOIDBACH, Member

GREGORY T. COSTELLO, Member

EXHIBIT G

FINAL PRESCRIPTIONS

11.1 GUIDELINES FOR IMPLEMENTING MASS WASTING PRESCRIPTIONS

Hazards to Private Resources

The Acme Watershed Administrative Unit (WAU) contains many private residences and structures. Some of these private structures are located on naturally hazardous landforms, including debris flow fans, alluvial fans, stream terraces and on areas directly below steep hillslopes prone to failure. Some, but not all, of these naturally hazardous landforms have been identified and mapped by Whatcom County Planning Department (1992). This watershed analysis does not attempt to map all of the hillslope and fan hazard areas in greater detail. Nor does it attempt to map hazard areas in relation to private structures, since the number and location of such structures occurring on naturally hazardous areas will change over time. Therefore, we recommend that potentially hazardous land forms, such as debris flow and alluvial fans, streamside areas and areas below steep hillslopes, be identified during preparation for specific forest practice activities, although the Acme watershed analysis and the Whatcom County alluvial fan hazard maps can be used as general guides.

Impacts to private property, as opposed to public resources, are not formally considered in watershed analysis (WFPB, 1994), which means that vulnerability of private property to identified hillslope hazards is not determined, and rule calls with respect to private property are not developed because they are not public resources. However, the team conducting the Acme watershed analysis considered impacts to private property and recommends that mass wasting prescriptions developed for high and moderate mass wasting map units be applied on a voluntary basis in those areas of the Acme WAU where there is an absence of fish-bearing channels but that contain private property vulnerable to mass wasting.

Map Resolution Issues

The slope stability assessment contained in watershed analysis is based on up-to-date scientific information on landsliding and the effects of forestry activities on landslide initiation, and therefore, forestry-related landsliding is expected to be substantially reduced when potentially-unstable landforms are identified in the field and prescriptions are followed. However, in some cases, areas of potential landslide hazard may not have been identified accurately during a watershed analysis (or any slope stability assessment) because of: 1) the dependence on remote-sensed data (i.e. aerial photographs); 2) the relatively short (40yr) and unique history of storms that triggered the landslides used to create the mass wasting map units (e.g. longer and different time periods and larger storms than what occurred during the aerial photo record may yield landslides in areas previously mapped as low landslide potential); and 3) the incomplete scientific understanding of all landslide mechanisms. For all of the above reasons, the mass wasting map units and hazard units developed during this watershed analysis may not completely identify all of the potentially unstable areas. In addition, because of the inherent difficulty in recognizing the exact combination of failure mechanisms at each site, the recommended prescriptions may not in every case reduce or eliminate forestry-related landsliding. Furthermore, naturally-occurring landsliding, that is not related in any way to forestry activities, can present a significant natural hazard to public (and private) resources, and these landslides cannot be predicted, nor at times can they be differentiated from landslides related to land use activities.

Implementation of prescriptions that apply to mass wasting hazards in the Acme WAU require the identification of mass wasting map unit (MWMU) boundaries in the field by the proponent. The identification and field verification of map unit boundaries shall be accomplished during preparation for forest practice activities by using the descriptions, based primarily on slope gradient, slope form, and evidence of past landslides which are listed in Table 3-2 of the mass wasting module. As part of the forest practice application, the applicant shall clearly identify the locations of ARS MW-1, ARS MW-2, and ARS MW-3 or state that none of the above were found in the proposed forest practice. A detailed forest practice preparation narrative shall accompany Forest practice applications that implement prescriptions applicable to mass wasting hazards. The narrative shall explain decisions made in cases where prescriptions offer flexibility, such as in the cases of wind throw prevention measures and bedrock hollow crossing structures.

Specialist Qualifications

To qualify as a **Geotechnical Specialist**, an individual shall have at least (i) either: (A) a Master's degree in geology or geomorphology or a related field or (B) a significant amount of post-graduate course or thesis work or other training in geomorphology or mass-movements; and (ii) an additional 5 years of field experience in the evaluation of relevant problems in forested lands.

To qualify as a **Forest Engineer** for the purposes of advising on road construction prescriptions, an individual should have a minimum of five years of appropriate field experience and either a bachelor of science degree in forest engineering or specialized education related to the location, design and construction of roads in mountainous terrain. For issues related to slope stability, a forest engineer must have specialized education or training related to slope stability in forest environments.

To qualify as a **Forester,** an individual must have a minimum of five years of applicable field experience and either a bachelor of science degree in forestry or an associates degree in forestry and have specialized education or training related to slope stability in forest environments.

11.2 CAUSAL MECHANISM AND PRESCRIPTION REPORTS

Acme WAU
Report #1

Resource Sensitivity: ARS MW-1

Input Variables:	Debris flow scour and deposition; channel aggradation; coarse and fine sediment (and woody debris)
Hazard:	Moderate or High
Vulnerability:	High (Fish habitat) High (Public Works)
Rule Call:	Prevent or avoid

Situation Statement:

Debris flows and dam-break floods from MWMU #1, MWMU #2, MWMU #3, MWMU #4, MWMU #5, MWMU #7, and MWMU #10 have the potential to deliver large volumes of coarse and fine sediment to water and fish habitat in Channel Segments #5 and #6. Coarse sediment deposition could also impact public bridges and adjacent roadways (Bridges #7 through Bridge #13, and Bridge #17 on the Public Works map). Debris flow deposits could bury channel roughness elements (boulders, LWD) and fill pools. Loss of these channel obstructions could increase average water velocities, reduce new pool formation rates, and reduce localized storage of spawning gravels. Aggraded channels allow greater sub-surface flow, which would extend periods of dry channels during low flow seasons. Fine sediments (<0.85mm) have the potential to degrade rearing and spawning habitat in Channel Segments #1, #4, #5, and #6 by filling pools and reducing spawning gravel suitability. Suspended sediment can also affect fish when delivered in sufficient quantity and duration.

Map Unit Description and Process

Please refer to the Mass Wasting Assessment for more detailed description and discussion of these MWMUs.

MWMU #1 and MWMU #4 are convergent topography greater than or equal to 36 degrees (73%), and include bedrock hollows, channel heads, AND inner gorges (see landform definitions) of first-order channels. These map units are naturally prone to landsliding, and are the primary source of debris flows. To see field examples of bedrock hollows, refer to photographs in: *Slope Instability and Forest Land Management, A Primer and Field Guide*, 1997/1998, Benda, L., Veldhuisen, C., Miller, D., Miller, L., Earth Systems Institute, Seattle, WA, 84 pages (see Appendix).

MWMU #2 and MWMU #5 are inner gorges, greater than or equal to 40 degrees (84%) in Chuckanut Formation or greater than or equal to 36 degrees (73%) in phyllite terrain, along second-- and higher-- order channels which contain all slope forms (convergent, divergent and planar). Landslides in these map units may trigger debris flows or dam-break floods.

MWMU #3 is generally non-convergent topography, greater than or equal to 31 degree (60%) hillslopes with primarily thin soils (3 to 6 feet). Bedrock hollows can occur here in various forms of development. The oldest features are deeply incised with sideslope gradients typically in excess of 45 to 50 degrees. In these cases, the drainage divide of a mature hollow may be 500 to 700 feet from the hollow axis (for photo examples of bedrock hollows, see Benda et al (1998)). Note that the actual drainage divide of a hollow is likely a subtle break in slope as the hollow slowly breaks into a planar or divergent surface. These strongly convergent and steep hollows are the most potentially unstable.

Hollows in earlier phases of development (i.e., younger) also exist in the Acme WAU and are characterized by more subtle convergence with slide slope gradients ranging from 30 to 40 degrees (the hollow axis may also be less steep). The drainage area of these hollows (also referred to as "wedges" by Buchanan (1998)) can be relatively small, and the drainage divide of small hollows may extend less than 100 to 200 feet away from the hollow axis. These sites are less potentially unstable since they should have a lower convergence of soil and groundwater. It is possible that small hollows that are filled with soil will be difficult to detect in the field. Likely locations of small hollows are at the heads of first-order or type 5 streams.

Although the relative stability is greater than MWMU #1, #2, #4 and #5, MWMU #3 also contains inclusions of convergent topography greater than or equal to 31 degrees (60%), including inclusions of MWMU #1.

MWMU #7 is an undifferentiated mixture of MWMUs #1, #2, #3, #4, and #5, as well as stable topography. MWMU #7 can also contain areas described by MWMU #6 (Devil's Slide), although the approximate perimeter of the Devil's Slide area is demarcated by MWMU #6 in Figure 3-3.

MWMU #10 is generally planar topography, 31 to, but not including, 36 degree hillslopes with primarily thick soils adjacent to inner gorges in phyllite terrain which contains all slope forms (convergent, divergent and planar). Although the relative stability is greater than MWMU #1 and MWMU #2, landslides in this map unit may trigger debris flows or dam-break floods. Landsliding mechanisms include shallow and small (<200 square feet) deep failures, including earthflows.

Landform Definitions

Some *signs of instability* that could be used to define MWMU #1, MWMU #2, MWMU #3, MWMU #4, MWMU #5 and MWMU #10 include:

i) existing landslides and old landslide scarps;
ii) discontinuity surfaces as described in the Mass Wasting Assessment pg 3-19 (Buchanan, P. 1988, Debris avalanche and debris torrent initiation, Whatcom County, Washington, U.S.A. MS thesis, Department of Geological Sciences, University of British Columbia);
iii) tension cracks*;
iv) scarp and bench topography indicating rotational slumps*;
v) tipped and jackstrawed trees*;
vi) springs and hydric vegetation.
(* more indicative of deep-seated failure sites, rather than shallow-rapid landslide sites)

A *channel head* is generally located in a convergent area, often at the base of one or more hollows, where subsurface flow emerges and a channel, defined by banks and substrate, begins.

A *high-hazard bedrock hollow* is defined as an unchanneled swale or valley with a slope gradient downhill along the axis of the hollow greater than or equal to 36 degrees (73%). Hollows may also contain the channel head; an area often characterized by springs and small landslide scars, where a channel is first identifiable. The more convergent the hollow the higher the likelihood of failure. Swales with no soil because of recent failure may present minimal hazard. The unstable portion of the hollow scales with the size of the landform. Small (narrow) landslides may occur in small narrow hollows along inner gorges. Wider landslides may be more representative in broader hollows on high relief hillslopes. Field measurements and aerial photographs indicate that the potentially unstable portion of hollows on high-relief hillslopes (see Mass Wasting Assessment) may range from 4 to 40m wide centered around the hollow axis, and the distance from ridgetops to the tops of landslide scars may range between 20 and 260m (average= 60m) and the potentially unstable portion may encompass the bottom 75% of the hollow length. Field surveys revealed landslide within hollows that ranged from 4 m (13 ft) to 12 m (40 ft) and averaged 7 m (23 ft). The potentially unstable zone of any hollow, therefore, needs to be determined in the field based on these guidelines, the size of the hollow and landform, and the signs of instability outlined above (i.e. "i - vi"); also see the guidelines in Benda, et al., 1998 (Appendix 1). The width of the zone shall be expanded by a minimum of 15 feet on either side to account for tree roots intersecting the failure plane and shall extend from the bottom to at least 75% of the entire length of the hollow. The zone shall be further extended to encompass those areas exhibiting significant signs of instability (see below).

A *moderate-hazard bedrock hollow* is defined as an unchanneled swale or valley with a slope gradient ranging from 31 to, but not including, 36 degrees downhill along the axis of the hollow. The more convergent the hollow the higher the likelihood of failure. Swales with no soil because of recent failure may present minimal hazard. Identifying the potentially unstable portion of a moderate hazard bedrock hollow should follow the same guidelines described for high hazard to increase the likelihood of mass wasting or contribute to the magnitude of a potential failure. Such roads would preferably be of a temporary nature, but it is recognized that permanent access for management activities will be necessary on some primary road systems.

If roads are constructed within these mass wasting units:

A. Stream and hollow crossing structures (e.g. bridges, culverts, fords) shall utilize keyed rock fills and be designed by a qualified forest engineer for a 100-year peakflow event. Structures shall be designed to allow passage of upslope failures. Crossings shall be surfaced with non-erodible materials such as hard rock, concrete, or asphalt.

B. All road and stream-crossing structures within inner gorges, bedrock hollows, and channel heads shall be designed, slope-staked, and field referenced by a qualified forest engineer prior to submittal of the forest practices application. In addition, all road construction shall be supervised on site by a forest engineer. Road lengths and widths within the mass wasting unit should be minimized to the extent that they remain compatible with safety requirements regarding the movement of logging trucks and yarding equipment.

C. All design drawings shall be included with the Forest Practice Application.

D. Full bench end haul construction techniques shall be utilized within these mass wasting units and in all cases on slopes greater than, or equal to, 60 percent where there is potential for sediment delivery to public resources.

E. Road drainage shall be designed to minimize water accumulation in ditches and prevent diversion between sub-drainages. This requires immediate passage (culvert, ford, or waterbar) at all drainages crossed by the road, including ephemeral channels and seeps. In addition, frequent cross drainage shall be installed at suitable locations to drain water accumulations from ditches. Suitable cross-drain locations feature a stable cut-slope and drain onto ridges or other stable slopes. Outfalls shall not be located in inner gorges unless consistent with natural drainage patterns.

F. Fine-scale secondary slope stability assessment by a qualified geotechnical specialist is required. The assessment should follow the approach and methods outlined in the most current version of the mass wasting module and should answer, at a minimum, the following questions: Will water be diverted into the MWMU? Will the hillslopes above or below the road be destabilized? Will the road fills be stable?

WASHINGTON STATE DEPARTMENT OF
Natural Resources

JENNIFER M. BELCHER
Commissioner of Public Lands

April 4, 2000

To All Interested Parties

Re: Acme Watershed Analysis Final Prescriptions

It has been brought to our attention that your copy of the final prescriptions for the Acme Watershed Analysis Unit (Exhibit G) may inadvertently be missing page 6. Attached is a copy of that page.

All exhibits associated with the above mentioned settlement agreement, along with other information related to the Acme WAU are available for review at the Northwest Region DNR office. A Request For Public Record form must be submitted with any request to review public records and are available at the NW Region office.

Please contact Jim Cahill at 360-856-3500 for further information.

NORTHWEST REGION ▮ 919 N TOWNSHIP ST ▮ SEDRO-WOOLLEY, WA 98284-9395
FAX: (360) 856-2150 ▮ *TTY: (360) 856-1371* ▮ *TEL: (360) 856-3500*

bedrock hollows.

An *inner gorge* is defined as the valley floor and hillslopes adjacent to a stream channel where hillslopes greater than or equal to 36 degrees extend a minimum relief of 5 meters (16 feet) above the channel.

> Slope gradients should be measured at the scale of small landslides (i.e. tens of meters). Only planar and divergent slope forms are covered in these hillslope gradient classes. The hillslope gradient cutoff does not include bedrock hollows located in inner gorges. Bedrock hollows located in inner gorges are defined by the slope gradients previously described for MWMU #1, #2, #3, #4, and #5. When landslides are observed on planar or divergent slope forms on hillslopes adjacent to streams, the slope gradient of the landslide head scarp should be used to define nearby hillslope gradients that are at risk from landsliding.

Triggering Mechanism(s):

Timber harvest reduces rooting strength in the soil and thereby can increase landslide frequency for approximately 5 to 20 years following harvest. A secondary effect of canopy removal is increased moisture inputs during rain-on-snow conditions, which can increase local soil moisture and contribute to slope failure. Failure of road fills may trigger landslides and debris flows. Water concentrated by road drainage can increase pore water pressures thereby decreasing slope stability. In the absence of forest practice activities, heavy precipitation or rain-on-snow events alone may trigger landslides and debris flows in any of the MWMUs. Although most slope failures appear to be associated with roads, it was not possible to determine the relative importance of these individual factors in triggering landslides since most inventoried landslides are old, road failures have been repaired, and remote sensing was the primary tool used during the watershed analysis. However, site-specific assessments of landslide prone areas may identify the relative importance of these factors to improve understanding of triggering mechanisms. In some instances windthrow has initiated shallow-rapid landslides. Timber harvest triggering mechanisms do not apply to MWMU #10.

Prescriptions:

- **New Road Construction**

  Proposed new road construction shall, in most instances, select alternatives that avoid MWMU #1, MWMU #2, MWMU #3, MWMU #4, MWMU #5, and MWMU #10. In rare instances, a well-engineered road may provide greater environmental protection than other alternatives (e.g. one crossing rather than multiple switchback roads up parallel ridges). In such cases, the DNR may permit road construction if the landowner can demonstrate that a full range of alternatives have been considered and that the chosen alternative is not expected

G. Crossing and drainage structures, as well as associated stabilization measures must, be completed before moving construction equipment from the site.

H. Construction will occur only during periods of suitable weather conditions, typically from May 15 to October 15.

I. Stream crossings located in channels that do not meet inner gorge criteria but are located upstream of adjacent inner gorge features shall meet the standards established in A through D above.

- **Reconstruction**

Reconstruction of orphaned, abandoned, or inactive roads in ARS MW-1 must meet the same standards as new construction. Road segments within ARS MW-1 originally constructed using sidecast cut and fill methods will require sidecast pullback unless otherwise authorized by the department following on-site review.

- **Existing Roads (Active and Inactive)**

Existing road segments within ARS MW-1 shall be inventoried and mapped for inclusion with the landowner's road maintenance plan. Inventory information shall identify areas of sidecast cut and fill construction, culvert locations and size, and native fills (see road maintenance plan requirements: ARS SE-1). Road maintenance shall not place any additional sidecast material within ARS MW-1.

- **Orphaned Roads**

For the purposes of these prescriptions, orphaned roads are defined as roads constructed prior to and unused for forest practice activities since the effective date of the Forest Practices Act of 1974. Landowners shall review all orphaned roads lying within the harvest unit or within 500 feet, either upslope or downslope, of any proposed timber harvest or road construction (including reconstruction) activity. These orphaned roads shall be mapped and unstable road segments identified as part of the Forest Practices Application or Notification. Concurrent with Forest Practice activity, instability problems shall be remediated, if practicable, on any orphaned road segment which is delivering or has the potential to deliver significant coarse sediment (i.e. mass failures or active gullying) to streams or to roads (proposed or existing).

- **Timber Harvest**

<u>General</u>

Evaluation of the hazard and impact of windthrow on inner gorge and high-hazard bedrock hollow leave areas shall consider comments and references presented in the appended project report, Evaluation of fall 1998 windthrow in slope stability leave areas at the Jones Creek and Hardscrabble harvest units (Veldhuisen, 1999). Appropriate management strategies shall be employed wherever, in the opinion of DNR, windthrow would substantially reduce the function of the leave area.

The goal of this prescription is to avoid loss of root strength within the potentially unstable feature. At times, harvest boundaries may be located along an abrupt edge demarcating an inner gorge or a high-hazard bedrock hollow. Trees located along the edge (i.e. straddling the boundary) may be contributing some lateral root strength. If there are numerous mature trees below the edge, then trees along the boundary may not be necessary to provide root strength. The removal of a portion of the trees overlapping the boundary may be allowed, where in the opinion of DNR, removal does not significantly reduce the rooting strength within the potentially unstable feature. Edge trees should not be harvested if there exists tension cracks or unvegetated landslide scars immediately below the boundary, or if there are very few trees on the unstable feature, or if the slope break is less than 4 degrees.

Inner Gorges of First and Higher Order Streams

No harvest on inner gorge slopes greater than or equal to 36 degrees (73%).Where inner gorge slopes extend beyond 100 feet slope distance from the high water mark, harvest may be allowed in the area beyond 100 feet from the high water mark if supported by a slope stability report prepared by a qualified Geotechnical Specialist. The report must assess the impact of the proposed harvest on slope stability, including rooting strength, and must be approved by the department as part of a complete application. No trees within inner gorges shall be used as tail-holds.

Minimal tree removal may be permitted without a geotechnical report to provide corridors for full-suspension skyline yarding provided that:

A. Skyline yarding would avoid otherwise necessary road construction, particularly when the only road access option would require road construction across these mass wasting units.
B. Corridor placement results in minimal cutting of trees.
C. Location of corridors shall be free of significant signs of instability.
D. Falling and yarding operations shall result in minimal soil disturbance.
E. Total corridor area shall not exceed 15% of the riparian area in the harvest unit.

High-Hazard Bedrock Hollows

Harvesting shall not occur in the potentially unstable zone of high hazard hollows (i.e.

greater than, or equal to 36 degrees (73%)) where there is a potential for delivery to waters or public capital improvements. Delineation of hollows into zones of stability must be performed by a qualified Geotechnical Specialist, Forester, or Forest Engineer. (as defined in Section 11.1). No trees within these unstable portions shall be used as tail-holds.

Moderate-Hazard Bedrock Hollows

Harvesting shall not occur in the potentially unstable zone of moderate hazard hollows (i.e. 31 to 35 degrees) where there is a potential for delivery to waters or public capital improvements unless the proposed harvest is supported by a report prepared by a qualified geotechnical specialist and approved by the department. The report must assess the proposed harvest and potential impact on slope stability, including rooting strength. Delineation of hollows into zones of stability must be performed by a qualified Geotechnical Specialist, Forester or Forest Engineer. No trees within these unstable portions shall be used as tail-holds.

Steep Slopes Outside of Inner Gorges and High-Hazard Bedrock Hollows

No harvesting on slopes greater than or equal to 36 degrees where significant signs of instability exist and landslides are predicted to reach or adversely effect water, fish, or capital improvements of the state or its political subdivisions. (See appended project report <u>Method to Predict Landslide Runout on Non-Convergent Hillslopes</u> by Lee Benda, Ph.D.)

Technical Rationale

The ability of landslide debris to enter stream channels depends on their runout characteristics. Although there are published runout models for channelized debris flows, there are no published models for landslide debris movement on non-channelized (planar) slopes. To circumvent this problem, a runout model was developed in the Acme watershed analysis by Dr. Lee Benda, based on the theoretical principle and empirical finding that landslide debris, which contains a relatively rigid (non-shearing)plug on the surface, will spread and thin, and deposit. A landslide runout model was developed based on this concept using published equations for shear stress of landslide debris and empirical data on runout geometry from the Acme WAU.

The landslide runout model for non-convergent hillslopes is currently being tested using data from the Oregon Dept. of Forestry. The model, however, should be used cautiously since it has not been rigorously tested. The model should be used in conjunction with other field indicators of instability and topography by experienced field practitioners. The accuracy of the model should be periodically evaluated by comparing model predictions with actual runout distances of landslides on non-convergent hillslopes.

The prescriptions are designed to prevent road failure hazards (e.g. fill failure, water concentration) during the winter storm season. Site-specific review and analysis are intended to identify which engineering techniques address and mitigate causal mechanisms.

Harvesting prescriptions are designed primarily to maintain an effective level of rooting strength and secondarily to avoid increased moisture inputs during rain-on-snow and soil disturbance from harvest activities within unstable areas.

Most landslides identified in the mass wasting module occur in bedrock hollows. The greatest number (72) of landslides occurred in high-hazard bedrock hollows (>=36°), but a relatively large number (54) also occurred in moderate-hazard bedrock hollows (31-35°). However, field study has indicated that approximately 90% of randomly selected bedrock hollows that had failed in clearcuts had slopes >=36°.

Although significantly fewer landslides (2) were recorded for planar slopes, the mass wasting assessment assigns a moderate hazard rating for 31 to 35 degree planar slopes (MWMU #3B) and a high hazard rating for greater than or equal to 36 degree planar slopes (MWMU #3A). In light of low failure frequency we have chosen to allow conventional harvesting techniques in MWMU #3B and have applied a no harvest prescription to portions of MWMU #3A with potential delivery.

Additional field assessment (See appended project report Acme WAU: Inner Gorge Topography, Landslide Inventory, and Management Practices by Lee Benda, Ph.D.) was conducted to better define landslide prone sites located within inner gorges in Chuckanut Formation. All 26 of the inventoried landslides occurred on slopes ranging greater than or equal to 40 degrees (84%). Seventy-five percent (75%) of the slides occurred in hollows with the remaining 25% located on planar slopes. On the basis of this data, prescriptions prohibit harvesting on steep inner gorge slopes of any form (>=40°).

These prescriptions are expected to reduce potential impacts to fisheries resources and water quality by reducing fine and coarse sediment inputs from mass wasting and limiting riparian disturbance (which contributes to temperature problems) caused by landslides and/or channel aggradation.

Mass wasting issues associated with existing roads will be dealt with according to road maintenance plans.

CAUSAL MECHANISM AND PRESCRIPTION REPORT
Acme WAU
Report #2

Resource Sensitivity: ARS MW-2

Input Variables:	Primarily rockfall, possibly debris flows
Hazard:	High (with respect to road construction that alters the distribution of surficial bedrock) Low (for timber harvesting alone)
Vulnerability:	High (Fish habitat)
Rule Call:	Prevent or avoid

Situation Statement

Rock avalanches from MWMU #6 have the potential to deliver large volumes of coarse sediment to water and fish habitat in Channel Segments #5 and #6. Sediment deposits could bury channel roughness elements (boulders, LWD) and fill pools. Loss of channel obstructions could increase average water velocities, impede pool formation, and lessen localized storage of spawning gravels. Aggraded channels allow greater sub-surface flow which would extend periods of dry channels during low flow seasons.

Map Unit Description and Process

MWMU #6 is the Devil's Slide area which contains relatively large-scale fracturing of bedrock with bedrock slabs gradually (or rapidly) moving downslope to the base of the ridge. This type of failure apparently arises because of large topographic stresses in combination with weak rock or by faulting. The role of groundwater (and therefore vegetation) appears to be minimal since the failure begins at the ridgetop and the failure is occurring in bedrock. Hence, timber harvest probably would not increase probability of bedrock slab failure. Road construction, however, that removes bedrock thereby changing the distribution of the rock mass or that significantly concentrates shallow groundwater flows along failure zones may contribute to bedrock slab failures.

Areas within MWMU #6 may contain shallow failures and landforms of the type described in MWMUs #1, #2, #3, #4 and #5. Since MWMU #6 is underlain by MWMU #7, these other types of slope failures (and landforms) are included in MWMU #7 and are discussed in Causal Mechanism and Prescription Report #1.

Triggering Mechanism(s)

Timber harvest probably does not play a role, although road construction that removes bedrock or significantly concentrates runoff may increase the probability of failures. Topographically-induced stresses in conjunction with weak sandstone bedrock is the predominant triggering mechanism, although faulting may also be important.

Prescriptions

- No new roads which require bedrock removal are to be built through MWMU #6. Road drainage patterns shall ensure that significant concentrations of ditch flows do not occur.
- Any other ARSs, and associated MWMU, located within MWMU #6 shall be mapped and identified in the field. All pertinent mapped information shall be included with the forest practice application, and all relevant prescriptions related to these other MWMU shall apply.

Technical Rationale

The prescriptions are designed to avoid changing the surficial distribution of bedrock and the distribution of hillslope water.

CAUSAL MECHANISM AND PRESCRIPTION REPORT
Acme WAU
Report #3

Resource Sensitivity: ARS MW-3

Input Variables:	Coarse and fine sediment
Hazard:	High (for road construction and blasting
	Moderate (for timber harvesting alone)
Vulnerability:	High (Fish habitat)
Rule Call:	Prevent or avoid

Situation Statement:

Deep-seated and shallow landslides, debris flows, and dam-break floods from MWMU #9 have the potential to deliver large volumes of coarse and fine sediment to water and fish habitat in Channel Segments #5 and #6. Mass wasting deposits could bury channel roughness elements (boulders, LWD) and fill pools. Loss of channel obstructions could increase average water velocities, impede pool formation, and lessen localized storage of spawning gravels. Aggraded channels allow greater sub-surface flow which would extend periods of dry channels during low flow seasons. Fine sediments (<0.85mm) have the potential to degrade rearing and spawning habitat in Channel Segments #1, #4, #5, and #6 by filling pools and reducing spawning gravel suitability. Suspended sediment can also affect fish when delivered in sufficient quantity and duration. Delivery of coarse and fine sediment onto the alluvial fan may pose hazard to structures and public works.

Map Unit Description and Process

MWMU #9 are large (>200 square feet), deep-seated landslides contained mostly within highly weathered phyllite bedrock but are found in Chuckanut Formation as well. The boundaries of the landslide are only approximately mapped. There are smaller, rotational slides within the main body of the slide mass which have the most potential instability, particularly when material is removed from the toes (of the smaller areas of instability). Sediment delivery should be minimal unless failures are immediately adjacent to stream channels. However, it is possible that deep-seated landslides located away from the channel can deliver sediment; this situation should be determined in the field.

Triggering Mechanism(s)

The triggering mechanisms for these slides are not well understood, since the large scale feature is mostly dormant. Recent harvest activity has occurred on portions of these slides, but insufficient time has passed for evaluation of the effects of harvesting. It is recommended that recent harvesting be assessed through periodic aerial photo analysis and field surveys to determine whether timber harvest or road construction contributes to failures.

Harvesting of trees on the active portion of a slide can reduce evapo-transpiration (ET) which may potentially lead to accelerated movement. In addition, harvesting of trees in the groundwater recharge zone (GRZ) can also potentially increase soil creep or failure rates (Miller and Sias, J. 1997). The effect of reduced ET on either the active slide area or in the GRZ in the Acme WAU is unknown at present. Hence, an approach is taken that focuses mitigation (no harvest or partial harvest) on the active portion of the slide area, with a lesser emphasis on the GRZ, until additional site specific information is available on the relationship between harvesting and landslide movement in the Acme WAU.

Similarly, new roads are more likely to contribute to movement when located on an active slide, due to drainage alteration and localized redistribution of soil masses. The primary concern regarding new roads within the GRZ and all existing roads is the potential for redistribution of water. Thus effective road drainage is critically important, especially during heavy rainfall events. Shallow landslides or debris flows initiated by roads on or above the deep-seated slide can have a serious destabilizing effect on deep-seated movement, as documented in the Warnick and Jordan/Boulder WAUs (1994 & 1996).

Prescriptions

Operations within map unit #9 must be preceded by a thorough field inspection for deep-seated activity within the area of the proposed activities and downslope to Jones Creek. The purpose of the inspection is to locate active slumps (generally indicated by recent cracking, tipped trees, etc.) and determine whether delivery to streams is occurring or is likely to occur with further movement. The inspection and assessment is to be performed by a qualified Geotechnical Specialist and a report submitted with the Forest Practices Application describing the methodology used and supporting information.

If evidence of recent (within several decades) slide activity is found, the inspector must determine the extent of the groundwater recharge zone (GRZ) of the active slide area, by considering topography as one would to delineate a drainage basin for a stream. The topographic limit to the GRZ can be identified using one of the following methods, listed in order of most precise to least:

1. Walking the boundary on foot, using a clinometer.
2. Marking a boundary on aerial photographs, from stereo inspection.

Once the active deep-seated landslide and its GRZ have been delineated, activities are limited as follows:

- **New Road Construction**

1. No new roads can be built through the active portion of a deep-seated failure.

2. For roads constructed within the GRZ, road drainage should be designed to minimize water accumulation in ditches and prevent diversion between sub-drainages. This requires immediate passage (culvert, ford, or waterbar) at all drainages crossed by the road, including ephemeral channels and seeps. In addition, frequent cross drainage shall be installed at suitable locations to drain water accumulations from ditches. Suitable cross-drain locations feature a stable cut-slope and drain onto ridges or other stable slopes. No additional water shall be diverted into the active slide area.

3. No road construction within the no-harvest buffers noted in the timber harvest prescriptions.

- **Reconstruction**

Reconstruction of orphaned, abandoned, or inactive roads in ARS MW-3 must meet the same standards as new construction. Road segments within ARS MW-3 originally constructed using sidecast cut and fill methods will require sidecast pullback unless otherwise authorized by the department following on-site review.

- **Timber Harvest**

No timber harvest in the active portion.

Timber harvest within the GRZ can occur under either of the following conditions:

1. Clearcut harvest operations must leave an uncut buffer along the upper margin of the active area, covering an area equivalent to 50% of the active portion.

2. Selective harvest operations must preserve a minimum relative density of 35 among residual stems greater than 25 years of age. Relative density is calculated by dividing the stand basal area per acre by the square root of the quadratic mean stand diameter at breast height.

3. Study by a geotechnical specialist indicates that slide activity did not increase following prior timber harvest and/or road construction. Such a study would require review of historical aerial photographs that would show slide conditions during the 30-year period following prior activities. The study should also involve a detailed site investigation of the area (e.g. the active or dormant landslide) to ascertain whether past harvest (or road construction) has led to failure. Field evidence would include new or old tension cracks that could be dated to the time of harvest or within 10 to 15 years after, split stumps, and displaced logging or spur roads. The conclusions of this secondary analysis must be

supported by complete scientific justification and be capable of withstanding technical scrutiny.

Technical Rationale

Without clear triggering mechanisms in the active deep-seated landslides in the Acme WAU, we cannot be certain of the effectiveness of any prescriptions. Therefore, we apply harvest restrictions based only on evidence of active deep-seated landslides. The harvest restrictions are intended to maintain evapo-transpiration by hydrologically mature timber on active deep-seated landslides and in a portion of the GRZ immediately above. Assuming that tree growth rates serve as a proxy for evapo-transpiration, the relative density minimum allows harvesting down to the lower level of the range in which maximum growth of pure Douglas fir stands occur.

These prescriptions are expected to contribute to improved water quality, by reducing fine sediment inputs from mass wasting and limiting riparian disturbance (which contributes to temperature problems) caused by landslides and/or aggradation.

Mass wasting issues associated with existing roads will be dealt with according to road maintenance plans required by these set of prescriptions.

Monitoring Recommendation

In an effort to gain a better understanding of the factors which influence its movement, it is recommended that affected landowners adopt and implement a program for monitoring active deep-seated landslides, particularly when harvesting within the GRZ. Monitoring may include annual site inspections or use of aerial photographs during 5-year reviews of watershed analysis.

CAUSAL MECHANISM AND PRESCRIPTION REPORT
Acme WAU
Report #4

Resource Sensitivity: ARS SE-1 (Applies to all road surfaces in the Southeast, Northwest and Southwest sub-watersheds)

Input Variables:	Fine sediment from road surface erosion
Hazard:	Moderate or High
Vulnerability:	High (Fish habitat)
Rule Call:	Prevent or avoid

Situation Statement

The N-1000 and other gravel roads in the Southeast sub-watershed produce substantial fine sediment, most of which is routed toward the Black Slough. Similarly, the many newly constructed roads in the Northwest and Southwest sub-watersheds contribute fine sediment to western tributaries (e.g. McCarty, Standard, Hardscrabble and Todd Creeks) and the South Fork Nooksack. Fine sediments (<0.85mm) have the potential to degrade spawning and rearing habitat by decreasing depth and volume of rearing habitat and reducing spawning gravel suitability. Suspended sediment can also affect fish when delivered in sufficient quantity and duration.

Triggering Mechanism(s)

SE Sub-watershed: Although many roads contribute, most sediment appears to originate from the primary haul road: N-1000. Most sediment is generated from the road surfaces due to hauling wear.

NW and SW Sub-watersheds: Most sediment is contributed from various recently-constructed (i.e. 1998 & 99) roads. Although much of the sediment is generated from the tread in response to hauling traffic, additional amounts come from recently exposed cutslopes.

Prescriptions

- **New Road Construction**

  New roads should be located to avoid stream crossings if possible. Where stream crossings are necessary, the length of ditches draining directly to streams shall be limited to 200 feet or less except when this spacing would place culvert discharge on unstable soils. Roads will be constructed in a manner that addresses mitigation of triggering mechanisms identified above. Competent rock surfacing will be used within direct entry segments on all-weather roads to reduce fine sediment production. Erosion control measures including mulching, grass seeding hydro-mulching, sediment, traps, and slope armoring shall be utilized on direct entry segments, at the time of construction. These erosion control measures shall be in place and functional by October 31st of the year in which the road was constructed. Road construction shall not occur between October 31st and May15th of each year unless otherwise approved by the department

- **Reconstruction**

Reconstruction of orphaned, abandoned, or inactive roads in ARS SE-1 must meet the same standards as new construction

- **Existing Roads - Active and Inactive**

<u>Required Road Maintenance Plans*</u>

Landowners who have forest road segments within the WAU (Figure 4-3) are required to submit a road maintenance and abandonment plan within six months of approval of this watershed analysis. The plan must specifically address correction of the following triggering mechanisms where there is direct potential for delivery to a public resource:

A. Direct entry of ditch water to streams (Board Manual recommendations page M-21)
B. Highly erodible native surfacing and/or inadequate surfacing
C. Poor road geometry (lack of crown, no inslope/outslope, rutting, berms)
D. Lack of cutslope and fillslope vegetation
E. Poorly constructed and inadequately maintained waterbars
F. Oversteepened cutslopes resulting in slumping and/or dry ravel

* (See ARS MW-1 for additional requirements for inventory.)

<u>Plan Implementation</u>

A. Implementation of this plan must begin within six months of approval of the road maintenance plan by the DNR and be completed within 24 months of approval of the road maintenance plan by the DNR;
B. Priority should be given to those road segments contributing more than 45 tons/year (see Table 4-3 and S4.1). Implementation for these segments must be completed within 12 months of approval of the plan unless an alternate timeline is approved by DNR as part of the plan;
C. Operations involving active haul on road segments contributing more than 45 tons/year prior to approval of the road maintenance plan must address and correct the triggering mechanisms A-F listed above concurrent with the

activity;

D. Where significant road maintenance, inactivation, or abandonment is planned, the location of waterbars, drainage dips, and cross drains must be marked on the ground prior to approval by the DNR

E. Additional cross-drains shall be installed along existing roads to limit the length of all ditches draining directly to streams to 200 feet or less except when this spacing would place culvert discharge on unstable soils. These cross drains are due within 1 year of approval of this watershed analysis or in conjunction with Forest Practice activities, whichever comes first.

Additional Requirements

A. Grading and ditch blading shall not occur during periods of weather or soil conditions that promote fine sediment delivery to surface waters, except when emergency repair is needed to prevent further resource damage.

B. Sediment traps and/or settling ponds shall be used and maintained on direct entry segments when hauling during wet-weather.

C. Implementation of road maintenance plans shall also include annual field inspections of all roads subject to the plans. Inspections shall be completed by August 1 of each year, and the identified maintenance needs completed by October 15 of that same year in order to ensure function of these structures. All prescriptions for new construction shall apply to these roads except that armoring of existing fills may be substituted for keyed rock fill where the existing fill shows no signs of instability.

Technical Rationale

SE Sub-watershed: Because most surface erosion is generated from the N-1000 road, reducing direct entry will substantially reduce the total sediment delivery. Less traveled spur roads are only minor contributors. New roads could produce substantial surface erosion, especially for first 1-2 years following construction.

NW and SW Sub-watersheds: A substantial number of new forest roads were constructed in 1997 & '98. Roads were generally built to high standards in terms of tread surfacing, drainage design that minimizes ditch entry to streams and efforts to revegetate cutslopes via grass-seeding. Still erosion research suggests that sediment production rates are elevated over the first two years following construction, until exposed soils become armored. Because there are many new roads undergoing this "seasoning" process, the total sediment contribution slightly exceeds the background rate of sediment from soil creep, indicating potential turbidity impacts.

Several additional segments of road construction are projected for 1999 and 2000 to reach currently inaccessible parts of the WAU. Once these roads are completed, road construction rates are expected to drop off sharply. Total road sediment inputs should drop considerably as the many roads built between 1997-2000 pass the two-year age mark when the basic erosion rates drop to one-half the rate for 0-2 year-old roads. Depending on the future condition of the road network (traffic, revegetation, abandonment, etc.) at that time, total road sediment inputs are projected to stabilize at levels associated with Low or Moderate hazard ratings.

Technical Note

Road surface sediment generated in the Southeast sub-watershed is much more likely to influence fish habitat in the Black Slough than the South Fork Nooksack. This is because the Black Slough is a very low-gradient stream that traps much of the fine sediment, reducing transport into the mainstem. Also, sediment input rates from the Southeast sub-watershed constitute a very small part of the total mainstem sediment load (<<1%), even on a per-unit-area basis. Of the fine sediment produced from roads in the Northwest and Southwest sub-watersheds, greater proportions are expected to reach the South Fork, due to steeper tributary gradients (compared to Black Slough) which allow more efficient transport. Still the contribution to the overall fine sediment load in the South Fork is relatively small, once compared to the large fine sediment volumes originating in the upper basin. However, the potential for sedimentation impacts in the relatively steep western tributaries is lower, compared to the Black Slough.

Voluntary Remedial Opportunity

Spur roads with ditches draining directly to streams should be abandoned and seeded with native grasses after harvest is complete.

Use of Central Tire Inflation (CTI) on logging trucks, if economically feasible, should be considered on all haul roads subject to surface erosion from truck traffic (See Moore, T., R.B. Foltz, and L. Cronenwett. 1995.

Resurfacing main haul routes with asphalt or with other non-erodible surfacing materials (e.g. chip seal, soil organic binder) would extend hauling periods and may allow all-weather hauling.

CAUSAL MECHANISM AND PRESCRIPTION REPORT

Acme WAU
Report #5

Resource Sensitivity: ARS R-1 **(South Fork and Mainstem of the Nooksack River and the channel migration zones (<0.001).)**

Input Variables:	Large woody debris (LWD)
Hazard:	Moderate or High
Vulnerability:	High (Fish habitat)
Rule Call:	Prevent or avoid

Situation Statement:

Conversion of the pre-settlement forest to agricultural land use has removed conifers and large deciduous trees from the floodplain of the South Fork and Mainstem of the Nooksack. This has greatly reduced recruitment of functional LWD to the channel and floodplain, thereby reducing channel complexity and habitat diversity. Floodplain modifications, including diking the mainstem, straightening the meanders, and draining slough channels, have greatly reduced the total area of riparian habitat on the floodplain. These floodplain modifications represent the largest and most persistent negative impact on fish habitat in the Acme WAU.

Triggering Mechanism(s)

Conversion of forest lands to non-forest production uses, primarily agriculture, has entailed a large net loss of riparian habitat and removed conifers and large hardwood trees. The residual riparian trees in non-forest lands typically consist of a thin screen of young hardwood trees along the streamside. Remaining areas of forest land consist of a dense forest of young hardwoods. LWD from young hardwoods decays swiftly and is subject to rapid downstream transport, and thus has little habitat value.

Prescriptions

No harvest can occur on or within 100 feet horizontally of the channel migration zone (see definition from Forests and Fish Report dated February 22, 1999 in Appendix. 11-7).

Technical Rationale

Application of this prescription for current conditions will have little effect on LWD recruitment and in-channel retention while the river is maintained in a constricted channel that provides few sites for LWD accumulation. Non-forest land uses currently preclude development of riparian forests adjacent to the river channel. This prescription will tend to remedy these problems and will provide improved fish habitat. This prescription , accompanied by relocation of existing dikes and rip-rap, will provide more extensive and greater improvement in fish habitat while possibly reducing flooding in downstream reaches.

Protection of a meander belt would allow the river to meander freely. Under such conditions, high streamflows from the South Fork and Mainstem of the Nooksack could deposit LWD in existing slough channels and would occasionally excavate new slough channels. The 100-foot no-cut buffer adjacent to the historical meander belt is necessary to maintain LWD recruitment to such channels at a sufficiently high level.

Voluntary Remedial Opportunity

Relocation of dikes and rip-rap to the limits of the identified historical meander belt (approximately equivalent to the 50-year floodplain) would allow the South Fork and Mainstem of the Nooksack to meander naturally, thereby creating slough channels and interacting (exchanging sediment, wood and water) with its floodplain. The Department of Natural Resources should relay the importance of this opportunity to Whatcom County officials so that funding sources, zoning laws, and other pertinent regulations can be modified/created to facilitate relocation.

CAUSAL MECHANISM AND PRESCRIPTION REPORT

Acme WAU
Report #6

Resource Sensitivity: ARS R-2 **(Floodplain tributaries (<=0.04) not including alluvial fans.)**

Input Variables:	Large woody debris
Hazard:	Moderate or High
Vulnerability:	High (Fish habitat)
Rule Call:	Prevent or avoid

Situation Statement

Conifers and large deciduous trees were removed from the riparian zone during conversion to agricultural usage, thus eliminating recruitment of LWD. Channel manipulations have largely removed in-channel LWD, thereby degrading fish habitat by reducing channel stability and complexity.

Triggering Mechanism(s)

Conversion of the pre-settlement forest to agricultural land uses has eliminated large trees and conifers from the riparian zone. Existing regrowth of small hardwood trees, limited to narrow corridors along the channels, produce woody debris which is relatively mobile and prone to rapid decay. Cutting these trees for timber or other reasons would further delay input of functional LWD.

Prescriptions

No harvest can occur within 100 feet horizontally of the ordinary high water mark of any potential fish habitat, including all Type 1,2 and 3 streams, as defined under current Forest Practice Rules at the time of application.

Technical Rationale

Studies cited in the riparian assessment suggest that a buffer width of 100 feet is necessary to ensure that the stream channels receives 90% of potential LWD recruitment and 90% of potential shade.

Voluntary Remedial Opportunity

Establishment of riparian forests in agricultural areas is desirable.

Artificial placement of large woody debris in pseudo-natural configurations could be effective for improving fish habitat, but only in channels not experiencing high inputs of coarse sediment.

CAUSAL MECHANISM AND PRESCRIPTION REPORT
Acme WAU
Report #7

Resource Sensitivity: ARS R-3 Alluvial fans (>0.04 and <=0.09).

Input Variables:	Large woody debris
Hazard:	Moderate or High
Vulnerability:	High (Fish habitat)
Rule Call:	Prevent or avoid

Situation Statement

Conifers and large deciduous trees have been eliminated from the riparian zone and other parts of alluvial fans, largely by conversion to agricultural usage, thus reducing LWD recruitment potential. Channel manipulations have largely removed in-channel LWD, thereby degrading fish habitat by reducing channel stability and complexity. Removal of large trees has also reduced the role of "barrier trees", which may reduce runout lengths of debris flows and dam break floods, potentially reducing damage to property and habitat.

Triggering Mechanism(s)

Conversion of the pre-settlement forest to agricultural land uses has eliminated large trees and conifers from the riparian zone. Selective timber harvest and residential development (i.e. Jones Creek) have reduced densities as well. Small residual hardwood trees produce woody debris which is relatively mobile and prone to rapid decay.

Prescriptions

No harvest can occur within 100 feet horizontally of the ordinary high water mark of any potential fish habitat, including all Type 1,2 and 3 streams, on the alluvial fans as defined under current Forest Practice Rules at the time of application. No harvest can be made of any trees growing in the barrier tree zone of the alluvial fan. The barrier tree zone contains all portions of the alluvial fan lying within 300 feet horizontal distance (660 feet in the case of Jones Creek) of the point where water from the upstream channel segment flows onto the alluvial fan (Figure 11-1). Other trees growing on the alluvial fans may be harvested, provided that all of the following conditions are met:

1. A maximum of thirty percent (30%) of the merchantable (>= 12 inch DBH) trees may be cut in any ten (10) year period.
2. The diameter distribution of merchantable trees must be maintained or shifted toward

a larger average diameter. The percent of conifer stems shall be retained or increased, as well.

3. Residual merchantable trees shall be relatively evenly spaced.
4. Minimum stocking levels for live residual merchantable trees is 75 trees per acre with a minimum diameter of 12 inches.

The lower and lateral boundaries of the alluvial fan can be delineated by finding the point of channel gradient change and projecting that elevational contour in both directions across the landscape to the points at which the projected contour no longer arcs back towards the upstream channel segment.

Technical Rationale

Alluvial fans are important spawning and rearing areas and warrant protection. Because of frequent debris recruitment by avulsion (i.e. rapid shifting of channel location during high flow events) and lateral channel migration, the 100-foot no-cut requirement is necessary to maintain the supply of large woody debris.

Trees growing on the upper portions of alluvial fans can serve as barriers to debris flows or dam-break floods. The 300 feet no-cut requirement at the apex of an alluvial fan ensures that these barrier trees will be retained. However, the degree of protection provided by this zone against debris flows and dam-break floods is not absolute, even with mature trees. The Jones Creek alluvial fan is particularly large and dam-break floods delivering to that fan could have severe impacts to public and private works; therefore an enlarged barrier tree zone is of greater value than elsewhere.

Even under natural conditions, channels on the alluvial fans move relatively frequently. The 30% harvest limitation, along with the distribution and spacing requirements, ensure that the average diameter of alluvial fan stands will increase towards trees large enough to contribute functional LWD and that these large trees will be distributed wherever new channels might be formed by avulsion.

Voluntary Remedial Opportunity

Establishment of riparian forests in agricultural areas is desirable.

Artificial placement of large woody debris in pseudo-natural configurations could be effective for improving fish habitat, but only in channels not experiencing high inputs of coarse sediment.

Figure 11-1. Barrier tree zone placement.

CAUSAL MECHANISM AND PRESCRIPTION REPORT
Acme WAU
Report #8

Resource Sensitivity: ARS R-4 **(Mountain channels (>0.09) and Upland channels below small lakes (0.02-0.06).)**

Input Variables:	Large woody debris
Hazard:	Moderate or High
Vulnerability:	High (Fish habitat)
Rule Call:	Prevent or avoid

Situation Statement

Conifers and large deciduous trees have been eliminated from the riparian zone along mountain streams by timber harvest, thereby limiting new recruitment of large woody debris and resulting in degraded fish habitat through a deduction in channel stability and complexity.

Triggering Mechanism(s)

Logging of the pre-settlement forest eliminated large trees and conifers from the riparian zone. Debris flows triggered upslope have also delayed the regeneration of conifers along streams. Small residual and regenerating hardwood trees produce woody debris which is relatively mobile and prone to rapid decay.

Prescriptions

For the purposes of these prescriptions, the anadromous fish barriers are approximately mapped and are the points on the streams where the lowest falls with a vertical drop of 10 feet or more exist or the stream gradient exceeds 20 percent.

<u>Below Fish Barrier</u>

No harvest within 100 feet horizontally of potential fish habitat as defined under current Forest Practice Rules at the time of application.

Minimal tree removal may be permitted to provide corridors for full-suspension skyline yarding provided that:

A. Skyline yarding would avoid otherwise necessary road construction, particularly when the only road access option would require road construction across these channels.

B. Corridor placement results in minimal cutting of trees.

C. Location of corridors shall be free of significant signs of instability.

D. Falling and yarding operations shall result in minimal soil disturbance.

E. Total corridor area shall not exceed 15% of the riparian area in the harvest unit.

Above Fish Barrier

No harvest within 50 feet horizontally of potential fish habitat as defined under current Forest Practice Rules at the time of application. Minimal tree removal may be permitted to provide corridors for full-suspension skyline yarding according to the conditions noted above.

Technical Rationale

Protection of non-fish habitat segments of these channels is likely provided for under the mass wasting prescriptions or under the "Riparian Prescription in Lieu of Causal Mechanism Report".

Voluntary Remedial Opportunity

Thin young, over-stocked hardwood stands to release existing conifer seedlings and/or interplant additional shade-tolerant conifer seedlings. Thinning young dense hardwood stands to release established conifers would accelerate production of functionally-sized woody debris and likely represents the most effective means of achieving prescription targets. In other instances, underplanting shade-tolerant conifer species may help accelerate the growth of large, decay-resistant woody debris for the future.

CAUSAL MECHANISM AND PRESCRIPTION REPORT
Acme WAU
Report #9

Resource Sensitivity: ARS R-5 **(Channel Segments 1,2,4,5,6,7, and 8.)**

Input Variables:	Shade
Hazard:	High
Vulnerability:	High (Fish habitat)
Rule Call:	Prevent or avoid

Situation Statement

Open riparian canopy along many channel segments does not cast shade sufficient to meet target levels, potentially increasing stream temperatures in these segments and downstream. Increased summer temperatures impair the function of these streams as salmonid rearing and holding habitat.

Triggering Mechanism(s)

Reduced riparian canopy is the result of land clearing for agricultural development and of timber harvesting. Reduced riparian canopy closure can adversely affect stream temperatures for salmonids by increasing the exposure to solar radiation.

Additionally, factors that increase the rate of exchange of stream waters and groundwater may adversely affect temperatures in large streams. Such factors for the South Fork include cutting the floodplain forests and the loss of most of the floodplain wetlands, resulting in a lowered low flow water table. Another factor is the loss of channel complexity due to diking of 60% the channel length, and the attrition/removal of 100% of the full spanning LWD jams. This has resulted in an 87% reduction in slough channels, a 40% reduction in the area of gravel bars, and a 50% reduction in sharp-angled (>60 degree) meander bends in this reach of the South Fork. Temperature impacts are likely to have occurred from reduced groundwater flow under gravel bars or across meander bends. Additionally sharp-angled channel meanders often develop very deep pools that may be thermally stratified and provide refuge habitat.

Prescriptions

No harvest of any riparian canopy cover can occur within 100 feet horizontally of fish habitat as defined under current Forest Practice Rules at the time of application until adequate shade levels are recovered. Nor can harvest of any riparian canopy cover occur within 100 feet horizontally of the ordinary high water mark of the first 1000 feet upstream of fish habitat until adequate shade levels are recovered. Adequate shade levels will be determined according to the temperature prediction method described by WAC 222-30-040.

Technical Rationale

Existing shade levels are not adequate to prevent temperature increases. Once adequate shade levels return, then timber harvesting can resume provided that riparian canopy cover is maintained at adequate shade levels. Existing shade levels are correlated with land use. Ninety-six percent of channels in agricultural areas were below target shade, and thirty-three percent of channels in forested areas were below target shade.

South Fork low flow temperatures can approach lethal thresholds for salmonids. This is of concern for adult migration and holding for spring//summer chinook, pink salmon, summer steelhead, and Dolly Varden/bull trout. Additionally, summer juvenile rearing habitat is impaired for all juvenile salmonids that would be expected to rear in the lower South Fork including stream type spring/summer chinook, coho, steelhead and cutthroat trout. Cooler areas including the lower portions of accessible tributaries, seeps, and other groundwater influenced areas including deep pools probably provide critical juvenile refuge habitat.

Voluntary Remedial Opportunity

Establishment of riparian forests in agricultural areas is highly desirable. Protection of floodplain wetlands is also very important.

Relocation of dikes and rip-rap to the limits of the identified channel migration zone (approximately equivalent to the 50-year floodplain) would allow the South Fork Nooksack River to meander naturally. This would increase the number of sharp-angled meander bends, thereby increasing the number of very deep pools. Restoring the meander belt would also increase the river's ability to form point bars (gravel bars) resulting in increased groundwater flow under gravel bars and across meander bends. Remediating the adverse summer temperatures in the South Fork is unlikely to be successful if stream shade is viewed as the only cause. The Department of Natural Resources should relay the importance of this opportunity to Whatcom County officials so that funding sources, zoning laws, flood hazard reduction, and other pertinent regulations can be modified/created to facilitate dike and rip-rap relocation.

RIPARIAN PRESCRIPTION IN LIEU OF CAUSAL MECHANISM REPORT

Assessment of large woody debris recruitment for Type 4 streams was not required by the version of Standard Methodology for Conducting Watershed Analysis under which this analysis was initiated. Member of the Prescription team expressed concerns that large woody debris recruitment would not exist along any Type 4 streams not subject to mass wasting prescriptions. To ensure a minimum level of large woods debris recruitment, all timber harvest operations are required to leave at least 25 conifer or deciduous trees, 6 inches in diameter or larger, on each side of every 1000 feet of stream length within 25 feet of Type 4 streams.

CAUSAL MECHANISM AND PRESCRIPTION REPORT
Acme WAU
Report 10

Resource Sensitivity: ARS WQ-1

Input Variables:	Shade
Hazard:	High
Vulnerability:	High or Moderate
Rule Call:	Prevent or avoid

Situation Statement

Open forest canopy adjacent to small wetlands (<10 acres) may not cast sufficient shade sufficient to prevent elevation of wetland water temperatures, potentially degrading water quality.

Triggering Mechanism(s)

Reduced wetland management zone canopy is the result of land clearing for agricultural development and of timber harvesting.

Prescriptions

Standard wetland management zone rules (WAC 222-30-020-7) apply except for the following:

1. The average WMZ width for Type B wetlands less than or equal to five acres shall be 50 feet.

2. Required leave trees shall be relatively evenly spaced.

3. Openings larger than dictated by spacing requirement (approximately 24 feet) are prohibited.

Technical Rationale

Standard rules could allow harvesting of all WMZ canopy on the southern edges of small Type A and Type B wetlands. The prescribed modifications ensure that adequate canopy will be distributed around the edges of such wetlands. The assessment classified four forested wetlands as depressional flow-through because of stream association. Because such wetlands are sufficiently protected by riparian shade and LWD prescriptions, no additional prescriptions were generated.